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VARIABILITY WITH TIME OF POOR VISIBILITY BESIDE A MOTORWAY

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SUMMARY

Analysis has been carried out of transmissometer readings recorded during occasions of poor visibility over the period from November 1974 to May 1975 beside the M4 motorway near Theale in Berkshire. Probabilities of given changes in visibility from various initial visibility ranges over different time intervals have been determined separately for rises and falls in visibility. Variations in these probabilities due to time of day and type of fog have also been explored.

INTRODUCTION

The occurrence of serious motorway accidents in recent years has increased public awareness of the dangers associated with sudden changes in visibility both in short time intervals and over short distances. This study has investigated temporal changes in visibility using readings taken beside the M4 motorway near Theale, Berkshire during the 1974–75 winter.

Similar work was carried out by Le Grice (1974, unpublished) using data from the Theale site and by Briggs (1969) using data from Heathrow Airport. The present analysis differs from that of Briggs in that a distinction is made between rises and falls in visibility; various extensions have also been made to the work of both Briggs and Le Grice.

Plots of air temperature, wind speed and humidity (which were all observed concurrently with visibility) were also examined in a search for associations which might help to predict short-term changes in visibility. The wet-bulb readings from which the humidity values were in part derived were found to be too unreliable during occasions of high humidity (often apparently higher than associated dry-bulb readings) to allow quantitative analysis. Short-period changes in the other parameters largely occurred at the same time as changes in visibility and so did not provide worthwhile precursor signals of short-term visibility changes.

INSTRUMENTATION AND DATA

The visibility recording instrument used was a modified Meteorological Office transmissometer with 100 m baseline and 40 second time constant. Voltage

readings associated with the sensor were transmitted by Post Office land-line every 15 minutes as routine. In addition, whenever the visibility was below 900 m transmissions were made every 2 minutes. Records ran from 15 November 1974 until 15 May 1975; in theory they were continuous, but in practice there were breaks due to transmission or instrumental faults. The 2 minute and 15 minute records were separate, so that occasionally when visibility was below 900 m only the 15 minute record was available. As the type of transmissometer used is incapable of discrimination below 50 m, all such readings were counted as 50 m.

Site

The transmissometer was situated on the north side of the M4 motorway about 400 m west of the Burghfield Road overbridge (National Grid Reference SU 669702) at a height of 45 metres above mean sea level. It stood 1·2 m above the road surface and 4 m from the hard shoulder of the motorway with the sensor facing east parallel to the motorway. The site is in rather flat surroundings with areas of lying water in the vicinity. A large conurbation including the town of Reading and several industries lies about 8 km to the north-east.

Data analysed

The analysis covered all periods during which the visibility was less than 1500 m and also the 70 minutes following each of these periods. Reference to the *Daily Weather Reports* indicated that none of these incidents was caused by rain; however, five were associated with snow and these five were omitted from this study. An 'occasion of fog' was defined as a period of visibility less than 800 m (excluding the above five episodes). Periods when the visibility rose above 800 m but failed to exceed 1500 m before returning below 800 m within 70 minutes were treated as one 'occasion'. Out of 182 days covered by the study, there were 26 'occasions of fog' totalling 111 hours on 26 different days; a total of 1730 visibilities were recorded in the range 50–799 m (including 375 observations of below 50 m which were counted as 50 m).

Method of analysis

Each visibility reading below 800 m (including those below 50 m taken as 50 m) was treated in turn as an initial visibility and the readings were first grouped into five classes (50–99, 100–199, 200–399, 400–599 and 600–799 m) which were analysed separately. Each initial visibility was then compared with readings made after time lags of 2,4,6,10,15,20,30,45 and 60 minutes, a tolerance of $\pm$ 10 per cent of each lag being allowed; the change in visibility in each case was then expressed as a percentage of the initial visibility and allocated to one of 17 categories of change (0–9, 10–19, ... 90–99, 100–149, ... 350–399, $\geqslant$ 400 per cent). Rises and falls in visibility were analysed separately for each class and lag. All comparisons for which *both* observations had been counted as 50 m were excluded from the analysis. To reduce the effects of missing values, linear interpolation, or if this was not possible, linear extrapolation from the last two readings, was used to estimate missing values, provided that the estimated visibilities were for times within 15 minutes of at least one of the available observations. For any particular initial visibility class and time lag the total of the estimated values was generally less than 10 per cent (nearly all less than 20 per cent) of the actual values. Any estimated values of less than 50 m were set to 50 m.

It should be noted that the greatest possible reduction in the initial visibility is 100 per cent, but that there is no such limit to the possible percentage increase in visibility. This skew effect is enhanced by the lower limit of 50 m in the resolution of the instrument, especially for the lower initial visibility classes; for example the maximum fall which can be measured in the 600–799 m initial visibility class is from 799 to 50 m, that is to say 94 per cent of the initial visibility, but it is only 50 per cent for the 50–99 m class and zero for the lowest values in this class.

Two forms of analysis were used. Method (i) treated the rises and falls as known separate categories within each initial visibility class and time lag. Method (ii) treated rises and falls separately but as percentages of the total of rises and falls together within each initial visibility class and time lag. For both methods cumulative percentages of occasions for which the percentage change in visibility exceeded a given value were derived for each initial visibility class and time lag (rises and falls separately).

Results

An example showing the results of the type (i) analysis for the 200–399 m class and for selected time lags (all hours of day) is given in Figure 1. The values of the ordinate are percentage probabilities of occurrence of specified changes in visibility, given that either a fall or a rise will occur. The graph illustrates the general findings that the greater the time lag the greater the probability of a given percentage change in visibility (true for rises and falls) and that the probability of a given percentage change in visibility occurring is greater for rises than for falls. Also deduced from graphs based on the type (i) analysis (not shown) is the fact that the greater the initial visibility the smaller is the probability of large changes, more especially for rises than for falls.

The above remarks relate to analyses based upon all hours of the 24 hour cycle taken together. They require modification when diurnal effects are considered (see section below headed 'Diurnal variations in probabilities of visibility changes').

Table I and Figure 2 present results for the type (ii) method, again for all hours of day. Table I displays the results for five time lags and all initial visibility classes and Figure 2 shows these results graphically for all time lags for the 200–399 m class only. The values in the body of Table I, corresponding to the ordinate on the graph of Figure 2, are percentage probabilities that, say, a fall in visibility will exceed a given percentage change, it not being known in advance whether in fact a fall will occur. Thus for a visibility in the 200–399 m class the probability is slightly above 0·05 that after 10 minutes there will be a fall exceeding 50 per cent of the initial visibility.

These type (ii) results, for all visibility classes considered, show similar features to those of the type (i) results described above, although owing to the small number of falls (relative to rises) in the 50–99 m class, the probabilities of falls from this initial class are considerably less than for higher initial visibilities.

Diurnal variations in probabilities of visibility changes

To study whether the various probabilities associated with visibility change reveal any diurnal variations each initial visibility was classified into one of six 'time-of-day' periods (00–04, 04–08, ... 20–24 h GMT) and the analysis

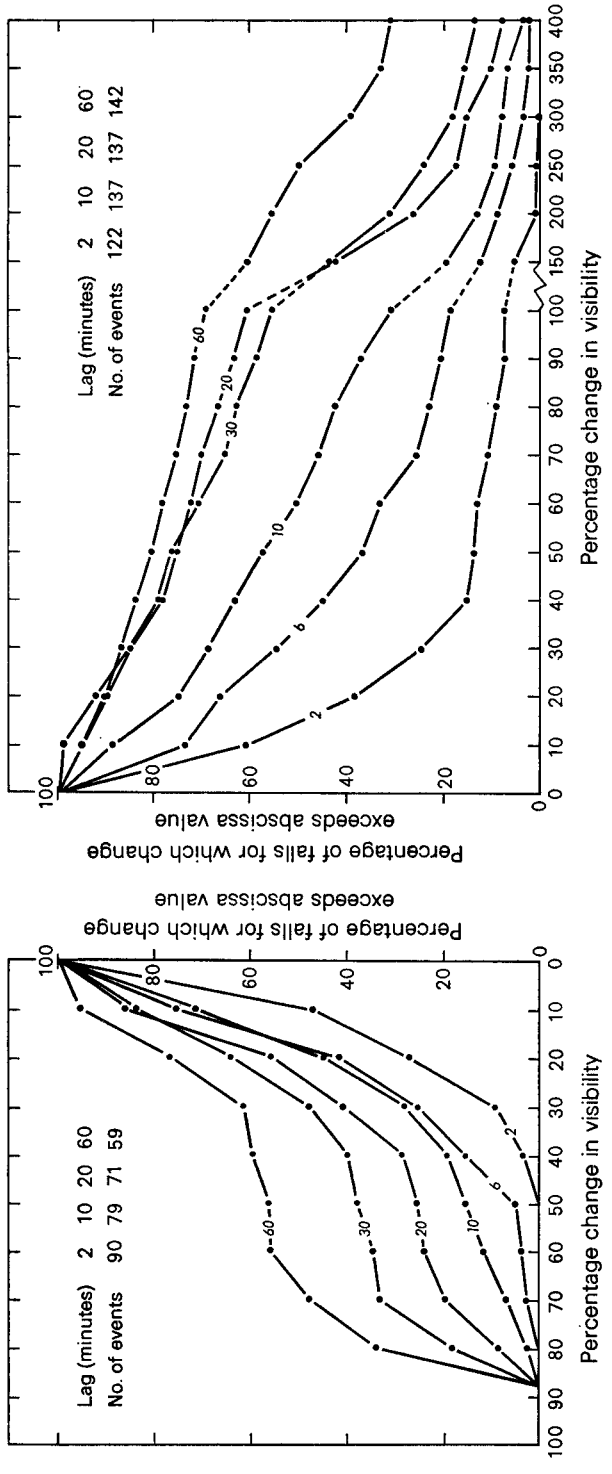
Lag (minutes) 2 10 20 60
No. of events 90 79 71 59
Percentage of falls for which change exceeds abscissa value
Percentage change in visibility
(a) FALLS
Lag (minutes) 2 10 20 60
No. of events 122 137 137 142
Percentage of falls for which change exceeds abscissa value
Percentage change in visibility
(b) RISES

FIGURE 1—PROBABILITY THAT (a) A FALL (b) A RISE WILL OCCUR EXCEEDING A GIVEN PERCENTAGE VISIBILITY CHANGE AFTER SPECIFIED TIME LAGS

Probabilities are expressed as percentages of corresponding total number of (a) falls (b) rises. All hours of day. Initial visibility in range 200–399 m. Italic figures on curves indicate time lags in minutes.

TABLE I—PERCENTAGE PROBABILITY THAT A FALL OR RISE IN VISIBILITY WILL OCCUR THAT EXCEEDS GIVEN PERCENTAGE VISIBILITY CHANGES AFTER SPECIFIED TIME LAGS, FOR DIFFERENT INITIAL VISIBILITIES

Time lag *minutes*	Initial vis. *metres*		Percentage visibility change																Total no. of occasions
			10	20	30	40	50	60	70	80	90	100	150	200	250	300	350	400	
2	50–99	F	11·6	5·0	2·5	0·8	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	42
		R	19·8	9·9	5·0	3·3	1·7	1·7	1·7	1·7	0·8	0·8	0·8	0·8	0·8	0·8	0·8	0·8	79
	100–199	F	14·5	7·3	3·6	1·8	1·8	1·8	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0 0	24
		R	38·2	25·5	18·2	12·7	5·5	3·6	0·0	0 0	0 0	0 0	0 0	0·0	0·0	0·0	0 0	0 0	31
	200–399	F	19·8	11·3	3·8	1·4	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0 0	0·0	0·0	0·0	0·0	90
		R	34·9	22·2	14·2	9·0	8·0	7·5	6·1	5·2	4·2	4·2	3·3	0·5	0·5	0·0	0·0	0·0	122
	400–599	F	15·7	7·3	2·4	2·0	1·2	0·4	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	116
		R	17·7	8·1	4·4	2·0	1·2	0·8	0·4	0·4	0·4	0·0	0·0	0·0	0·0	0·0	0 0	0 0	132
	600–799	F	8·1	3·8	1·7	1·1	0·4	0·0	0·0	0·0	0·0	0 0	0·0	0·0	0 0	0 0	0 0	0 0	238
		R	10·9	4·3	1·5	0·6	0·6	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	232
10	50–99	F	18·7	9·0	3·7	2·2	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	38
		R	53·0	32·1	26·1	19·4	18·7	16·4	12·7	11·9	9·0	7·5	7·5	4·5	4·5	3·7	3·7	3·7	96
	100–199	F	25·0	21·4	16·1	8·9	3·6	3·6	1·8	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	20
		R	51·8	50·0	48·2	39·3	35·7	35·7	30·4	28·6	28·6	21·4	12·5	8·9	5·4	3·6	3·6	1·8	36
	200–399	F	25·9	16·2	10·2	6·9	5·6	4·2	2·3	0·9	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	79
		R	56·0	47·7	43·5	40·3	36·6	31·9	29·2	26·9	23·6	19·4	12·5	8·3	6·0	5·1	4·2	2·3	137
	400–599	F	26·5	19·4	17·4	10·7	4·0	0·4	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	112
		R	39·1	22·9	18·2	15·8	13·0	8·7	6·7	5·1	4·7	4·3	2·8	2·0	0·8	0·0	0 0	0 0	141
	600–799	F	21·9	9·3	6·1	4·2	2·7	2·3	1·9	0·6	0·4	0·0	0·0	0·0	0·0	0 0	0·0	0 0	195
		R	33·3	16·8	10·1	7·4	5·5	4·8	3·6	3·2	1·9	1·3	0·2	0·2	0·2	0·0	0·0	0·0	280

F = Falls R = Rises

TABLE I—*continued*

Time lag *minutes*	Initial vis. *metres*		Percentage visibility change															Total no. of occasions
			10	20	30	40	50	60	70	80	90	100	150	200	250	300	350	400	
	50–99	F	18·5	10·6	8·6	2·6	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	40
		R	60·3	53·0	41·1	31·8	29·1	24·5	20·5	19·9	17·2	17·2	15·9	13·2	11·3	9·9	8·6	7·9	111
	100–199	F	27·3	25·5	21·8	16·4	14·5	5·5	1·8	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	19
		R	56·4	56·4	52·7	49·1	49·1	45·5	45·5	41·8	41·8	40·0	27·3	20·0	18·2	10·9	9·1	3·6	36
20	200–399	F	29·3	18·8	14·4	9·6	8·7	8·2	6·7	2·9	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	71
		R	62·5	59·1	55·8	51·4	49·5	47·6	46·2	43·8	41·8	39·9	27·9	17·3	11·5	10·1	6·7	5·3	137
	400–599	F	28·8	23·6	13·2	10·0	6·0	3·2	2·4	2·4	1·2	0·0	0·0	0·0	0·0	0·0	0·0	0·0	96
		R	49·6	35·2	23·6	19·6	17·2	14·4	12·8	12·0	11·2	9·6	6·4	3·6	2·8	2·4	2·0	0·8	154
	600–799	F	27·4	15·2	8·8	7·5	6·6	4·7	3·0	1·9	0·2	0·0	0·0	0·0	0·0	0·0	0·0	0·0	206
		R	42·4	28·5	18·8	12·6	7·9	7·3	6·4	5·8	5·4	5·1	3·0	1·3	0·6	0·2	0·2	0·0	261
	50–99	F	19·5	12·8	7·9	3·7	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	43
		R	67·7	59·1	52·4	43·3	39·6	32·9	29·9	27·4	26·2	25·0	22·6	18·3	16·5	14·6	14·0	12·8	121
	100–199	F	30·9	30·9	27·3	21·8	9·1	7·3	1·8	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	19
		R	58·2	58·2	56·4	56·4	56·4	56·4	54·5	52·7	52·7	50·9	43·6	38·2	36·4	32·7	27·3	25·5	36
30	200–399	F	25·6	19·6	14·6	12·1	11·6	10·6	10·1	5·5	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	61
		R	68·3	63·8	58·8	54·8	52·8	48·7	45·2	43·7	40·7	38·7	30·2	21·6	16·6	12·6	11·1	9·5	138
	400–599	F	26·8	22·4	19·1	17·5	12·2	5·7	5·3	5·3	2·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	83
		R	57·3	47·2	37·4	32·1	27·2	22·8	20·3	18·7	15·9	13·4	11·0	8·9	5·7	4·5	3·7	2·8	163
	600–799	F	27·1	16·6	10·1	8·7	6·7	3·6	1·8	1·6	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	167
		R	45·3	35·7	24·9	16·8	13·9	10·5	9·4	8·5	7·6	7·0	4·9	3·1	0·7	0·2	0·0	0 0	279

TABLE I—*continued*

Time lag *minutes*	Initial vis. *metres*		Percentage visibility change																Total no. of occasions
			10	20	30	40	50	60	70	80	90	100	150	200	250	300	350	400	
	50–99	F	18·7	13·6	8·4	2·8	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	48
		R	71·5	69·2	66·4	60·3	57·5	54·2	48·6	45·3	42·1	40·7	37·4	34·6	33·2	32·2	31·3	30·8	166
	100–199	F	25·9	24·1	20·4	20·4	14·8	9·3	3·7	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	14
		R	68·5	66·7	64·8	63·0	57·4	53·7	53·7	53·7	50·0	48·1	42·6	42·6	42·6	42·6	42·6	40·7	40
60	200–399	F	27·9	22·4	17·9	17·4	16·4	16·4	13·9	10·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	0·0	59
		R	67·2	63·7	61·2	59·2	56·7	55·2	53·2	51·7	50·7	48·8	42·8	39·3	35·3	27·9	23·4	21·9	142
	400–599	F	28·9	25·5	22·6	19·7	17·2	15·1	14·6	13·8	3·8	0·0	0·0	0·0	0·0	0·0	0·0	0·0	74
		R	64·0	55·2	46·9	40·2	36·8	32·2	29·7	28·5	23·8	22·2	17·2	15·1	8·8	5·4	4·2	2·1	165
	600–799	F	29·6	22·1	12·4	9·4	8·7	7·5	5·6	4·7	4·2	0·0	0·0	0·0	0·0	0·0	0·0	0·0	163
		R	52·1	41·3	33·3	25·8	20·0	15·3	12·7	10·6	9·9	9·2	6·3	5·4	2·8	2·3	1·6	1·2	263

F = Falls R = Rises

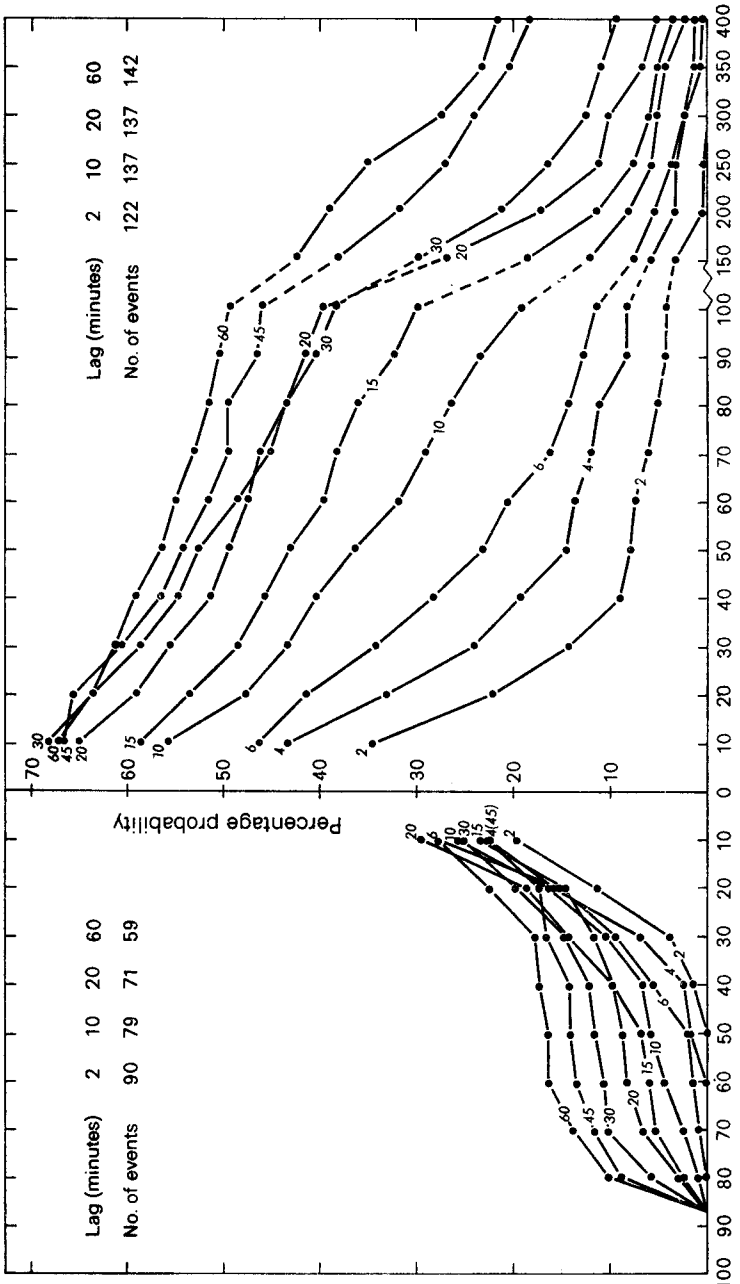
Lag (minutes) 2 10 20 60
No. of events 122 137 137 142
Lag (minutes) 2 10 20 60
No. of events 90 79 71 59
Percentage probability
Percentage change in visibility
(a) FALLS
(b) RISES

FIGURE 2—PROBABILITY THAT (a) A FALL (b) A RISE WILL OCCUR EXCEEDING A GIVEN PERCENTAGE VISIBILITY CHANGE AFTER SPECIFIED TIME LAGS

Probabilities are expressed as percentages of total numbers of falls and rises combined. Other remarks as for Figure 1.

repeated using the type (ii) method. Figures 3 and 4 display results for the 200–399 m class for the 04–08 and 20–24 h periods respectively and Figures 5 and 6 display corresponding results for the 600–799 m class.

The numbers of observations in each period are small and the detailed relationships complex. Plots of probabilities derived from Figures 3 – 6 for 50 per cent falls and for 25, 50 and 100 per cent rises against lag time were drawn for 04–08 and for 20–24 h GMT starting periods for both initial visibility classes in an attempt to clarify these relationships. The plots show that the probabilities for a 50 per cent fall are greater for all time lags for starting times in the 20–24 h than in the 04–08 h period for both initial visibility classes. For the 600–799 m class this is also true for rises of 25 per cent, 50 per cent and 100 per cent. For rises from the 200–399 m initial visibility class there is a tendency for the probabilities to be similar for the morning and evening periods for lags up to 20–30 minutes and then for longer lags the probabilities become higher in the morning period than in the evening period—for which after about 20 minutes' lag the probability decreases with increasing lag.

Variations in probabilities of visibility changes with type of fog.

The 26 'occasions' were separated into radiation and advection fog types by a subjective assessment using the Central Forecasting Office hourly charts. There were only four advection 'occasions' out of the total of 26; nevertheless type (i) analyses were carried out on the advection fog subsample for all hours combined (which in practice meant 20 h through midnight to 11 h for this subsample). The results for selected time lags and initial visibility classes are compared with the results for the total sample (which of course includes the advection fogs) in Table II. This shows that in general there is a lower probability of rises and falls in visibility in a given time lag and initial visibility class in the advection subsample than in the total sample (and hence than in the radiation subsample). This finding that advection fogs are less prone to change in visibility agrees with that of Chisholm and Kruse (1974).

Diurnal variations in occurrences of poor visibilities

To investigate a diurnal variation in occurrences of poor visibilities, times when the visibility (i) was below (with a maximum of one occurrence per 'occasion'), (ii) first fell below, and (iii) first rose above 1500, 800, 400, 200 and 100 m in each of the six four-hour periods 00–04, 04–08, ... 20–24 h GMT were determined. Results are displayed in Figures 7(a)–(c). Figure 7(a) indicates that the most likely period for visibilities less than 1500 m, 800 m and 400 m to occur is 20–08 h, for 200 m, 00–04 h and for 100 m, 00–08 h. Figure 7(b) shows 20–24 h to be the most favoured time for visibilities to fall below 1500, 800 and 400 m, and 20–04 h for falls below 200 m. Figure 7(c) shows a complex distribution depending on the visibility limit considered. The low frequency of rises above all the limits for the period 12–20 h is associated with the small number of poor visibility events encountered in this period.

Conclusion

The probabilities of changes of visibility expressed as percentage changes of the initial visibility are different for rises and falls and vary with the magnitude of the initial visibility and the time lag. They also vary with time of day and with type of fog.

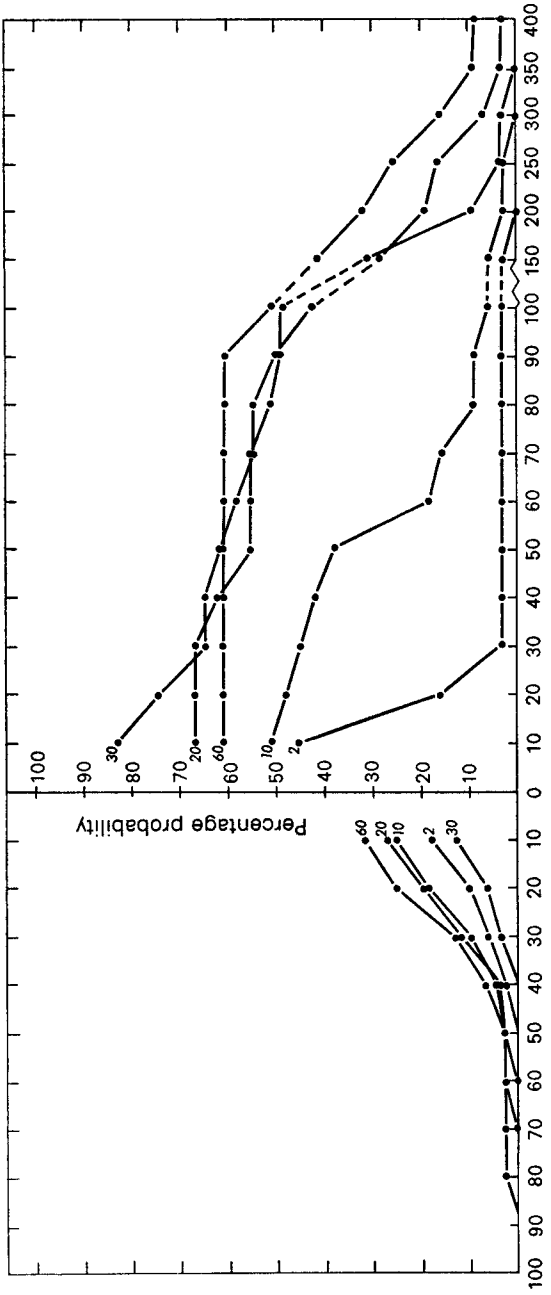

FIGURE 3—PROBABILITY THAT (a) A FALL (b) A RISE WILL OCCUR THAT EXCEEDS A GIVEN PERCENTAGE VISIBILITY CHANGE AFTER A SPECIFIED TIME LAG

Time period 04 h–08 h (starting times). Initial visibility in range 200–399 m. Average number of events: Rises 18, Falls 12. Values for lags of 60, 30, 20, 10, 2 minutes.

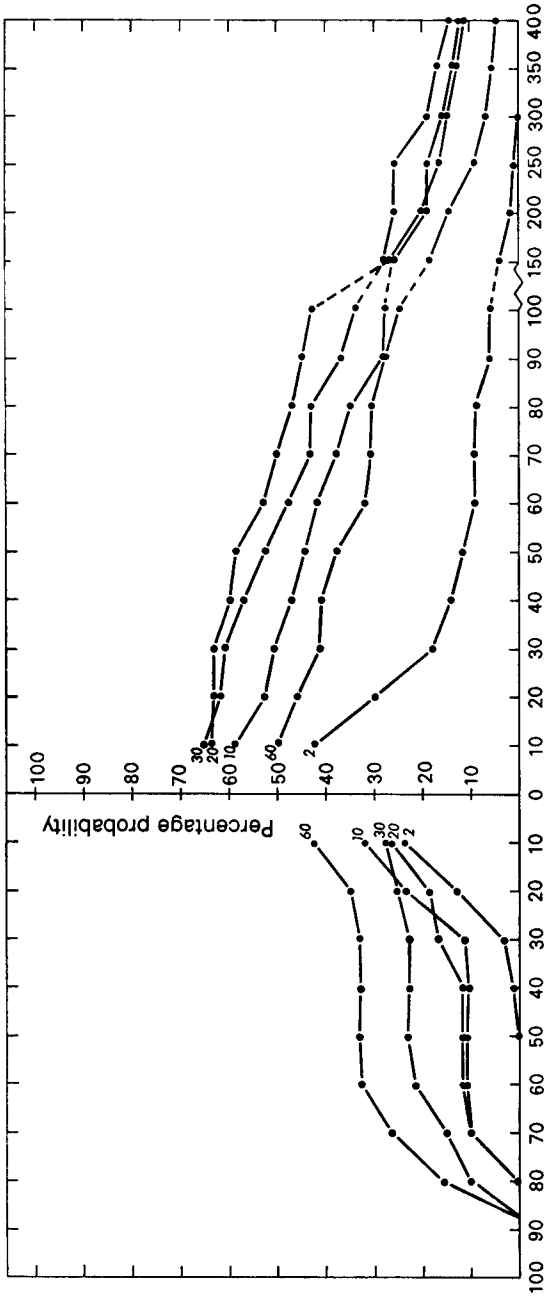

FIGURE 4—PROBABILITY THAT (a) A FALL (b) A RISE WILL OCCUR THAT EXCEEDS A GIVEN PERCENTAGE VISIBILITY CHANGE AFTER A SPECIFIED TIME LAG

Time period 20 h–24 h (starting times). Initial visibility in range 200–399 m. Average number of events: Rises 32, Falls 24. Values for lags of 60, 30, 20, 10, 2 minutes.

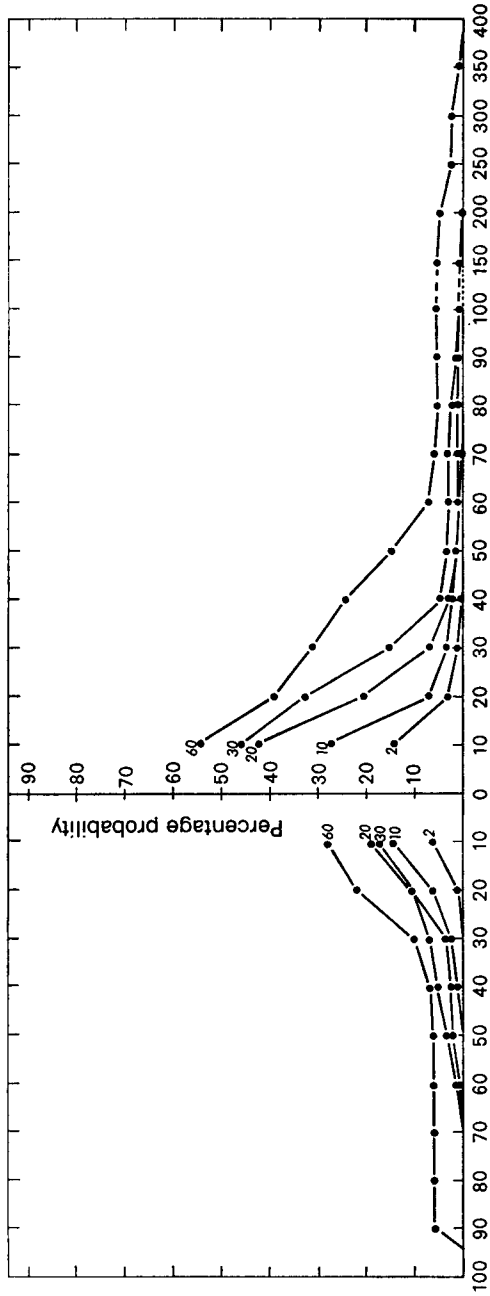

FIGURE 5—PROBABILITY THAT (a) A FALL (b) A RISE WILL OCCUR THAT EXCEEDS A GIVEN PERCENTAGE VISIBILITY CHANGE AFTER A SPECIFIED TIME LAG

Time period 04 h–08 h (starting times). Initial visibility in range 600–799 m. Average number of events: Rises 129, Falls 67. Values for lags of 60, 30, 20, 10 and 2 minutes.

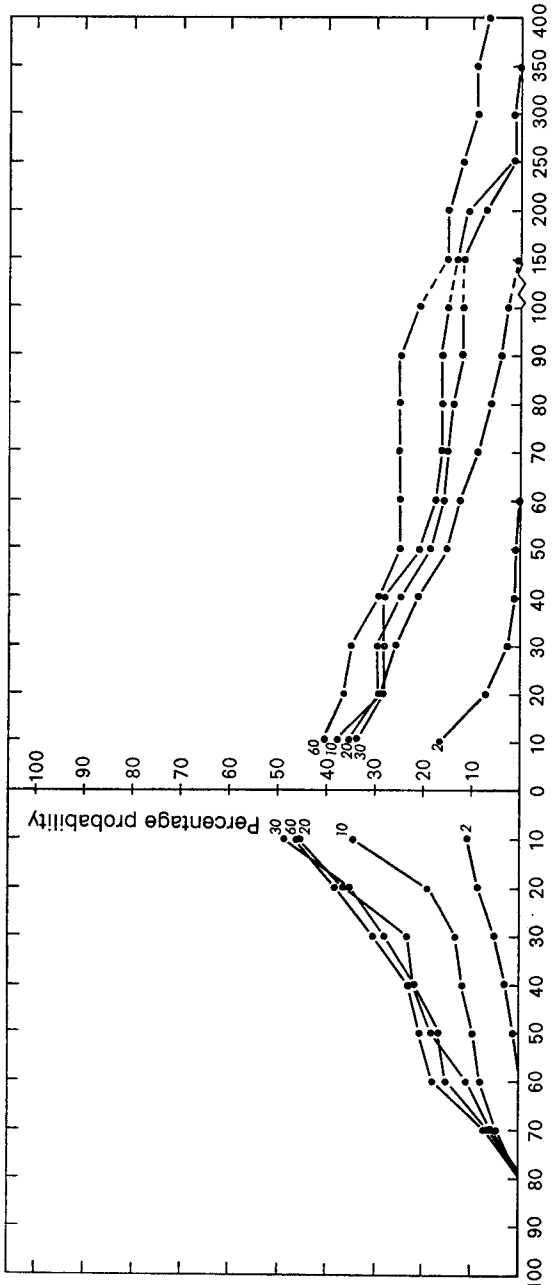

FIGURE 6—PROBABILITY THAT (a) A FALL (b) A RISE WILL OCCUR THAT EXCEEDS A GIVEN PERCENTAGE VISIBILITY CHANGE AFTER A SPECIFIED TIME LAG

Time period 20 h–24 h (starting times). Initial visibility in range 600–799 m. Average number of events: Rises 38, Falls 35. Values for lags of 60, 30, 20, 10 and 2 minutes.

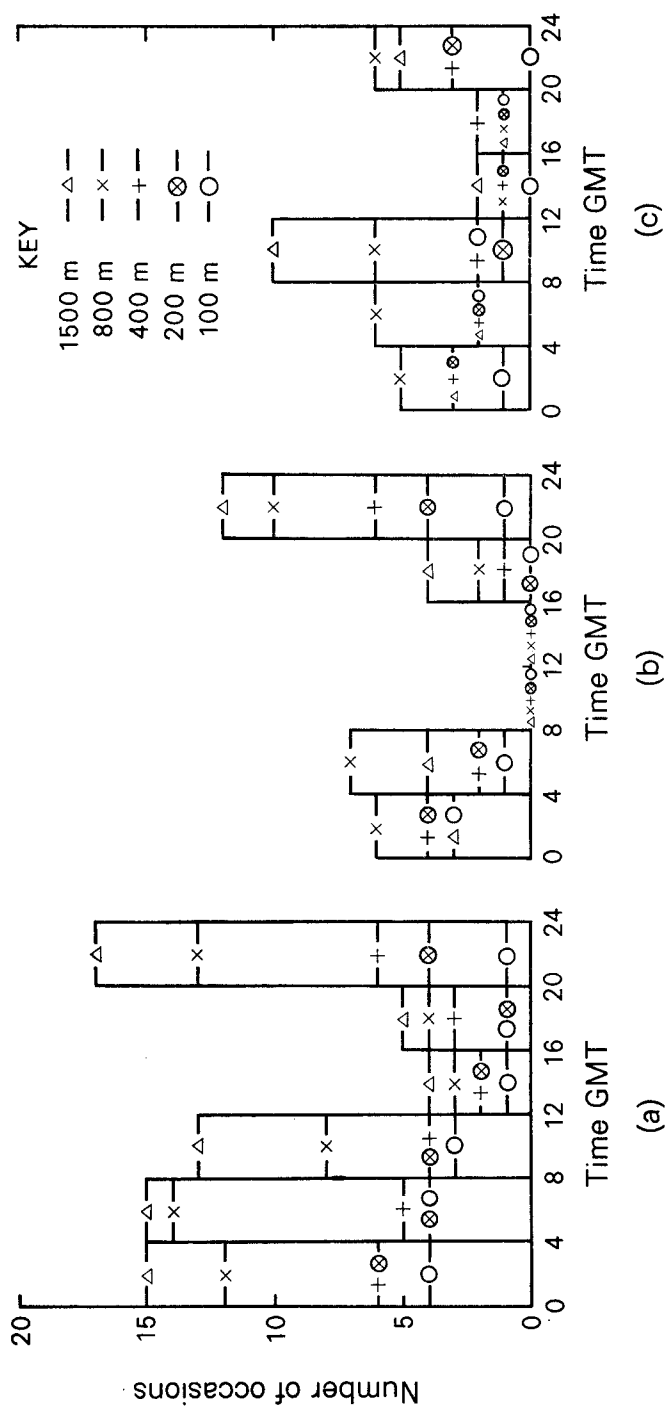

FIGURE 7—NUMBER OF OCCASIONS IN EACH TIME INTERVAL THAT THE VISIBILITY (a) OCCURRED (b) FIRST FELL BELOW (c) FIRST ROSE ABOVE, THE GIVEN VISIBILITY LIMIT

TABLE II—COMPARISON BETWEEN ADVECTION FOG AND TOTAL FOG SAMPLES. PERCENTAGE PROBABILITY OF GIVEN PERCENTAGE VISIBILITY CHANGES OCCURRING IN SPECIFIED TIMES FROM DIFFERENT INITIAL VISIBILITIES, FOR FALLS AND RISES SEPARATELY

Time lag	Initial vis.	Fall (F) or Rise (R)	Total (t) or Advection (a) sample	No. of obs.	Percentage visibility change										
minutes	*metres*				20	40	60	80	100	150	200	250	300	350	400
	200–399	F	t	94	23·4	3·2									
			a	10	10·0										
2		R	t	118	39·8	16·9	12·7	9·3	7·6	5·1					
			a	13	23·1										
	600–799	F	t	238	7·1	2·1									
			a	38	2·6										
		R	t	233	8·6	4·2									
			a	42											
	200–399	F	t	84	36·9	15·5	7·1	1·2							
			a	9	22·2										
10		R	t	132	78·8	66·7	53·0	44·7	31·8	19·7	12·1	7·6	6·1	5·3	3·0
			a	15	80·0	66·7	33·3	13·3							
	600–799	F	t	201	23·4	11·4	5·0	1·5							
			a	38	15·8	5·3									
		R	t	275	27·3	10·9	7·3	4·7	1·8	0·4	0·4	0·4			
			a	45	22·2	11·1	8·9	6·7							
	200–399	F	t	74	54·1	36·5	29·7	14·9							
			a	3	33·3										
30		R	t	142	91·5	78·9	69·7	62·0	54·9	43·0	30·3	23·2	18·3	14·8	13·4
			a	21	80·9	66·7	57·1	52·4	33·3	14·3	9·5	9·5			
	600–799	F	t	188	43·1	22·3	9·0	4·3							
			a	24	37·5	25·0									
		R	t	289	56·4	27·3	16·3	12·8	9·7	6·6	3·1	1·4	1·0	0·7	0·3
			a	59	30·5	18·6	18·6	15·3	10·2	5·1	5·1				

Blanks denote zeros.

For the 24 hours considered together, in general the lower the initial visibility and the longer the time lag the greater the probability of a change exceeding specified percentage rises and percentage falls. The probabilities of specified percentage changes are usually larger for rises than for falls, but this is largely due to there being lower limits to the possible percentage falls which can be observed. Percentage changes in visibility with increasing lag times for restricted periods of the 24 hours are more complex. In particular for rises in the 200–399 m initial visibility range in the period from 20 h to midnight, probable percentage changes in 60 minutes are less than those in 30 minutes and even in 10 minutes.

Percentage changes of visibility with time are less in advection fogs than in the more common radiation fogs.

ACKNOWLEDGEMENTS

I should like to thank the Transport and Road Research Laboratory and Mr H. A. Douglas (Meteorological Office) for making available the data used in this study, and Mr P. F. Lavington, who carried out programming for the work on diurnal variations in probabilities of visibility changes. I am also greatly indebted to Mr C. L. Hawson for his help and advice.

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551.593.653:77

HIGH-RESOLUTION CINE AND TELEVISION OBSERVATIONS OF NOCTILUCENT CLOUDS

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SUMMARY

An account is given of high-resolution cine and television observations of noctilucent clouds (NLC) made from Aberdeen in 1976 and 1977. The merits of the two methods are compared with each other and with other methods including stereoscopic phototheodolite observations. It is concluded that there remains much useful work which can be done with apparatus similar to that which was used at Aberdeen, and that the best recording medium for such observations is black and white cine film.

To face page 304

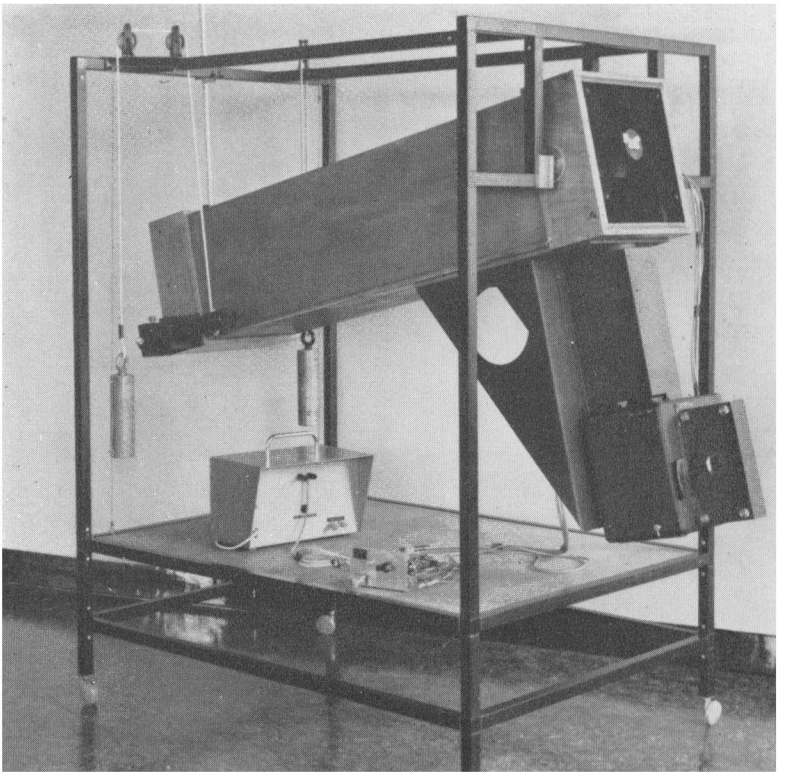

PLATE I—APPARATUS FOR HIGH-RESOLUTION CINE PHOTOGRAPHY OF NOCTILUCENT CLOUDS

PLATE II—ONE FRAME OF A CINE FILM OF NOCTILUCENT CLOUDS

Taken at 0050 UT on 21 July 1976 from Aberdeen. Exposure 19 s. Azimuth 027°, elevation 5·43°.

PLATE III—FIELD OF VIEW OF PLATE II

Note the twin spires of St Machar's Cathedral, Aberdeen, seen from Aberdeen University Natural Philosophy Department.

Photograph by M. Gadsden

Photograph by permission of the East Anglian Daily Times

PLATE IV—TORNADO DAMAGE AT NEWMARKET, 3 JANUARY 1978

See page 308.

To face page 305

Photograph by permission of the East Anglian Daily Times

PLATE V—TORNADO DAMAGE AT NEWMARKET, 3 JANUARY 1978

See page 308.

1. Introduction

Noctilucent clouds (NLC) are very tenuous, bluish-white clouds which occur near the mesopause, that is to say at altitudes of 80–85 km, during the summer months at high latitudes. They are most commonly observed on clear nights between 55° and 65° latitude when the sun is between about 6° and 14° below the horizon. Photographic records of NLC have been made ever since they were first observed, in 1885 (Jesse, 1890), and there is now a considerable photographic record of NLC from most parts of the world from which they have been seen (Fogle, 1966). Absolute determinations of the positions of NLC were made as early as 1887 (Jesse, 1890) by taking simultaneous photographs from two observing stations. Witt (1962) has produced the best stereoscopic photographic record to date, using a pair of phototheodolites with long focal lengths (380 mm) and recording the images upon glass plates. Witt's photographs show considerable fine detail, at scales of about one minute of arc, and give a good three-dimensional representation of NLC structure.

NLC features can be seen to move and change their form quite rapidly, and in order to record these movements it is necessary to use some kind of motion picture apparatus. Time-lapse cine films of NLC have been made on several occasions (Witt, 1964, for example) but the small film format (16 mm) and wide field of view has meant that cine films which have been produced have not had sufficient resolution to show the time development of the fine detail mentioned in the previous paragraph. In order to record the movements of such detail, a program of high-resolution motion picture observations of NLC was conducted at Aberdeen (57° 09′ N, 2° 08′ W); the methods which were used are described in the next section.

2. Apparatus and observations

The optical system which was used consisted of a Newtonian reflecting telescope with a 217 mm objective mirror of focal length 1·2 m, to which was attached a pair of photographic lenses to increase the effective aperture ratio to about *f*/2·5 (Plate I). The effective focal length was 530 mm, somewhat greater than the focal lengths of Witt's phototheodolites. Observations of NLC were made during the summer months of 1976 and 1977.

For the 1976 observations a 35 mm time-lapse cine camera was attached to the optical system, and Kodak High Speed Ektachrome film was used. About 10 m of film were successfully exposed on the night of 20/21 July 1976, with exposure times of 19 s and 8 s. Plate II is a black and white copy of one of the frames of the film, and Plate III shows the field of view in relation to a larger part of the NLC display. For the 1977 observations a Grant & Taylor GT50/NV television camera, fitted with an RCA 4804 S.I.T. tube, was used in place of the cine camera. About 30 minutes of videotape of NLC were recorded on the night of 22/23 June 1977.

3. Features of NLC which were observed

The most noticeable feature in Plate II is the billow-like structure which can be seen, particularly towards the top of the picture. On the assumption that the clouds are at 82 km altitude—all reliable NLC height determinations give heights close to this (Fogle, 1966)—the billows are from 1 to 5 km long, and have a crest to trough height of up to 1·8 km. If the billows are followed on the film, from

frame to frame, they are found to grow and decay with time constants of about 100 s, and they move with speeds of up to 100 m/s, presumably following the background wind motion. The television pictures show similar features, and also show that these features appear to turn over, giving some indication of the magnitude of the background wind shear—about 0·025 s^{-1}. A more comprehensive analysis of the movements observed is given elsewhere (Jenkins, 1978).

4. Comparison of methods

The *angular resolution* of the cine system was about 20 seconds of arc, for sharp objects. This is far superior to the angular resolution in photographs taken using short-focus lenses. It is about the same as the angular resolution of Witt's apparatus—NLC features with angular dimensions down to one minute of arc were observed in each case. Because Witt used two cameras, he obtained a good representation of the three-dimensional form of such features, but this was not the case at Aberdeen. The angular resolution of the television system was poorer—about one minute of arc for sharp objects, and considerably worse for low-contrast NLC features.

The *field of view* of the Aberdeen apparatus was 2·6° × 2° for both the television and the cine systems, so that the long waves and bands which are often seen in NLC displays could not be distinguished. In this respect, Witt's photographs were far superior, having a field of view of 25° × 16°, so that both large and small NLC structure could be seen.

The *sensitivity* of the High Speed Ektachrome film emulsion was found to be adequate, at 19 s exposure, for solar depression angles of at least 12°, but the colour rendering was poor at solar depressions of more than 11·5°. The sensitivity of the television camera was adequate for the solar depression angles encountered during the display of 22/23 June 1977, but these did not, however, exceed 8·5°.

Time resolution. The development of the billow-like NLC features in time was better represented by the Aberdeen cine and TV systems than by Witt's photographs, as the features could change shape completely in the five minute intervals between successive plates exposed by Witt. The amount of blurring due to movement of the NLC during the exposure will be less, for a given light level and aperture ratio, if a faster photographic emulsion is used. High Speed Ektachrome has a rated speed of 160 ASA, but this decreases to 80–56 ASA for exposure times of 1–10 s. The effective speed of an equivalent black and white emulsion (Kodak Tri-X Pan, rated at 400 ASA) is 400–280 ASA for the same exposure times. The exposure times for the *f*/2·5 cine systems (19 s and 8 s) were comparable to those for Witt's *f*/5 phototheodolite system (25 s–5 s). The difference in aperture ratio was compensated for by the slower emulsion speed of the High Speed Ektachrome in comparison with Witt's P1200 plates which were rated at 400 ASA, so that the amount of movement of NLC features during exposure, for similar light levels, should be about the same for both methods.

Colour representation. NLC differ from the background sky not only in their brightness, but also in their colour saturation*. Colour film should therefore give a better representation of them than black and white film, but this advantage is outweighed by the lesser sensitivity of colour film.

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* *Colour saturation* is the degree to which a colour departs from white and approaches the pure colour of a spectral line.

5. Conclusion

It is worth while observing NLC with as good space and time resolution as possible, for it is the small-scale structure of NLC and the short-time-scale changes in this structure which raise the most interesting questions and enable the most definite conclusions to be drawn about conditions near the mesopause (Jenkins, 1978). For such high-resolution observations, the previous discussion shows that sensitivity, angular resolution and time resolution have to be balanced against each other. The angular resolution and contrast of cine film are better than those of television, but a time resolution of one second may be necessary to avoid blurring. It is therefore necessary to use as fast a film as possible, which means that black and white film needs to be used for the best results.

There may be considerable advantage in using a combination of an image intensifier and a cine camera; present technology is capable of producing image intensifiers with light gains of 100 and more and resolutions better than 0·02 mm over an area 100 mm in diameter (Johnson, 1972). If there is structure present in NLC smaller than one minute of arc, the use of such an image intensifier may well be essential. Alternatively one can aim to record NLC movements using apparatus with a somewhat wider field of view, in order to show the long waves and bands. Thirty-five millimetre cine film remains the better recording medium, as its angular resolution is better than that of television. It is, however, necessary that the fine detail should still be visible, as it is the fine detail that gives an indication of the background wind.

There remains, however, a considerable amount of work which can still be done with apparatus similar to that used in Aberdeen. At the present stage, the apparatus has produced good records of only two NLC displays. It would be advantageous to obtain records of the drift and development of small structures from a greater number of NLC displays, in order to obtain a more representative picture of atmospheric motions in the neighbourhood of the mesopause.

Acknowledgements

This work was done while I was in receipt of a Science Research Council research studentship. I am most grateful to Dr P. Rothwell of Southampton University for the loan of the S.I.T. television camera, and to Dr R. Eather of Boston University for the 35 mm cine camera. I also thank Drs M. Gadsden and P. Wraight for many helpful discussions and suggestions made during the course of my work.

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551.515.3

THE NEWMARKET TORNADO OF 3 JANUARY 1978

By L. G. CHORLEY
(Meteorological Office, Royal Air Force Honington)

SUMMARY

A tornado struck Newmarket (Suffolk) on the morning of 3 January 1978. Available synoptic data show this to be an example of such development at a cold front.

INTRODUCTION

Press reports of a 'freak whirlwind' and 'American type twister' describe the four-mile trail of blitz-like damage from Newmarket Heath (west of the town of Newmarket) to Ashley (south-east of the town) on the morning of 3 January 1978, at about 0915 GMT. Roofs were ripped off, windows smashed, a railway signal box moved on its foundations (and severely damaged) and a car overturned (see Plates IV and V). Personal descriptions include one of 'seeing it coming like a corkscrew, dark with thunder and hail'. The path of the tornado was estimated to be about 70 yards wide. Elsewhere in East Anglia local damage would appear to have been due to the general strong winds (with gusts to about 65 knots). The nearest meteorological office to Newmarket is at Royal Air Force Honington, about 17 miles east-north-east of the area struck by the tornado.

METEOROLOGICAL SITUATION

A well-marked cold front crossed East Anglia during the morning of 3 January 1978, moving south-east at about 40 knots after having advanced from a midnight position just north-west of Ireland. By 09 GMT this front had reached the position shown on the surface chart in Figure 1. Hourly charts (not reproduced) show that the surface cold front crossed the Newmarket area at about 0930 GMT. There was some evidence on hourly charts of a pressure trough ahead of the surface cold front similar to that described by Miles (1962) and the general character of the weather just ahead of the front was that of a line-squall. However, a detailed analysis of the possible line-squall structure and history has not been attempted. Precipitation was in a narrow belt commencing ahead of the front, the sequence of observations at Honington being as follows:

Time (GMT)	Surface wind *degrees/kn*	Dry bulb/Dew-point *degrees Celsius*	Weather
0852	220/28 gust 51	7.9/3.7	Cloudy, no precipitation
0920	270/36 gust 60	—	Heavy thunderstorm with hail
0935	270/30 gust 37	1.7/—	Thunderstorm, heavy rain
0950	260/25 gust 33	2.1/1.9	Thunder, slight rain
1015	260/27 gust 36	—	Rain ceased

A marked pressure jump of 2·9 mb was recorded at Honington at 0917 GMT followed by the surface wind veer at 0920 GMT and marked temperature drop (of 6·2 °C) at 0925 GMT (see Figure 2). Several other stations recorded surface wind changes more in accord with the hypothesis of a pressure trough or line-squall ahead of the surface cold front. Marham (Norfolk) reported successive

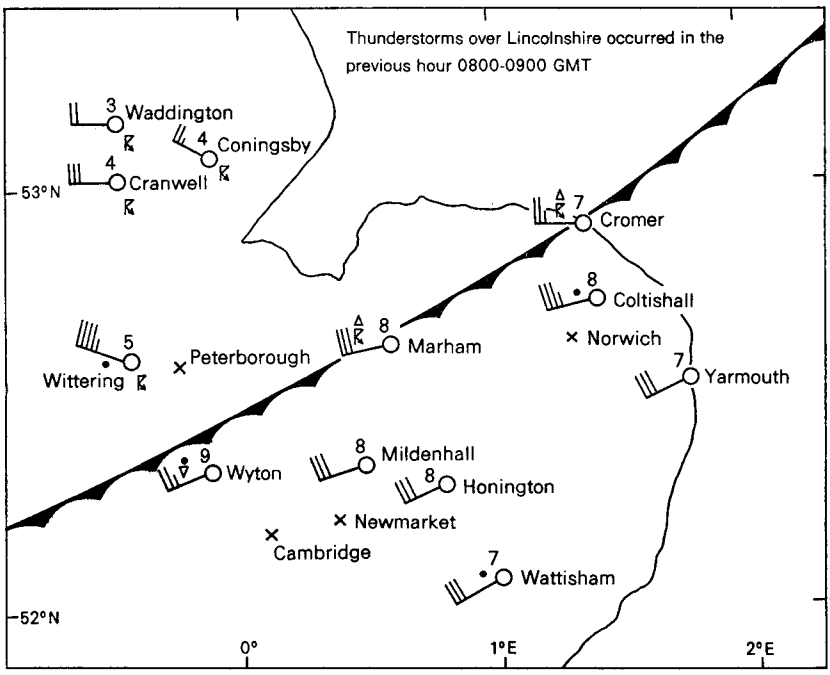

FIGURE 1—SURFACE COLD FRONT AND WEATHER AT 0900 GMT ON 3 JANUARY 1978

Note. The single figure plotted near each station circle denotes dry-bulb temperature in degrees Celsius.

hourly winds of 230°/26 kn, 250°/30 kn, and 290°/24 kn for the period 0800–1000 GMT, the pressure jump occurring about 20 minutes ahead of the surface front passage which was at 0915 GMT.

The total rainfall at Honington during the period 0920 GMT to 0950 GMT was 2·6 mm with a further 0·2 mm before the final clearance. Cloud structure ahead of the frontal zone was layer stratocumulus, altocumulus and cirrus, with rapid cumulonimbus development on the line-squall. Cloud lowered to 400 ft in the heavy rain, lifting soon after the frontal passage with breaks to well-scattered cumulus following at about 1030 GMT.

A tornado was also reported in the Hull area at 0710 GMT (just ahead of the surface cold front).

The observations and analysis are consistent with the conclusion that the tornado at Newmarket occurred on the passage of the line-squall just ahead of the surface cold front.

THE COLD FRONT

Data from the radiosonde stations shown in Figure 3 were used to construct the cross-section through the cold front which is shown in Figure 4. The full lines are wet-bulb potential temperatures and the shear zone, as determined by wind components parallel to the surface cold front, is shown by heavy dashed lines. Wind directions above the surface over East Anglia were generally between 270°

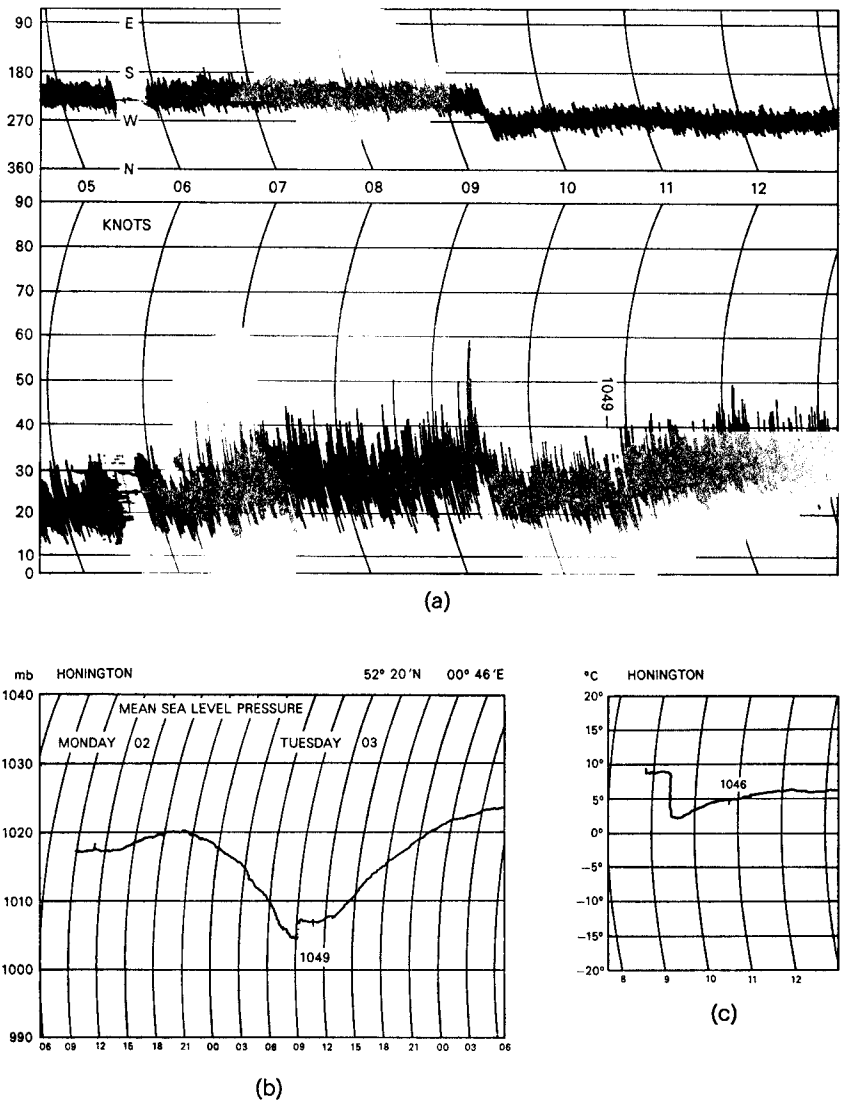

FIGURE 2—DIAGRAMMATIC REPRESENTATION OF AUTOGRAPHIC RECORDS AT HONINGTON FOR 3 JANUARY 1978

and 300° with a thermal wind directed across the surface cold front and a jet in excess of 100 kn at 300 mb (at 0600 GMT) lowering to 400 millibars by 1200 GMT. The front had the general characteristics of a kata cold front as described by Sansom (1951).

TORNADO DEVELOPMENT

The essential requirement for a tornado, as discussed by Wright (1973), is a strong persistent updraught through a deep layer—implying instability for the ascent of

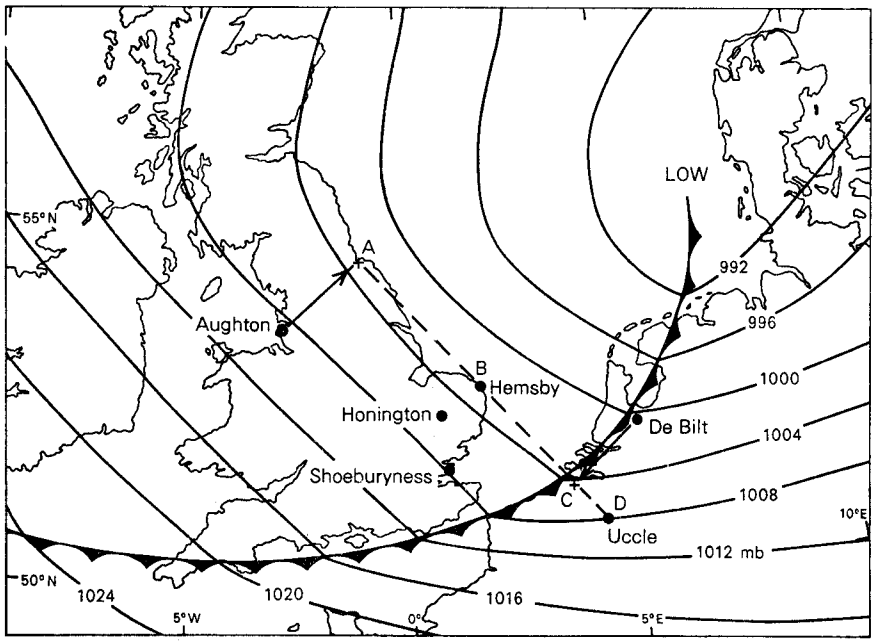

FIGURE 3—SURFACE ANALYSIS FOR 1200 GMT ON 3 JANUARY 1978

saturated air. The development is favoured if the air is potentially unstable, that is to say if there is a decrease of wet-bulb potential temperature with height. Profiles of temperature and humidity as measured by the available soundings for 3 January do not show marked potential instability; however, none of the soundings necessarily shows the precise characteristics of the air mass over Newmarket at the time of the tornado. Profiles of wet-bulb potential temperature are shown in Figure 5 which compares the Hemsby 1200 GMT data (in the post-frontal cold air) with data from a sounding carried out at Shoeburyness at 1002 GMT (air some 40 nautical miles ahead of the cold front). Honington surface observations give a surface wet-bulb potential temperature of about 6 °C just before the marked drop in temperature at 0925 GMT. If we allow for these warmer surface conditions and postulate over-running of the cold air at higher levels then a profile showing a decrease of potential wet bulb with height is obtained. Such over-running of the cold air is a common feature of kata cold fronts, as is the development of line-squall characteristics. Inspection of the cross-section in Figure 4 reveals that although no clear-cut 'cold nose' above the surface appears, some instability of this type is shown to a limited degree and the cold wedge (as defined by the wet-bulb potential lines) is very steep.

The fact that deep convection did occur with cumulonimbus cloud is evident from the actual weather observed. The marked temperature fall at Honington at 0925 GMT was probably due to heavy rain falling into unsaturated air. Wright (1973) associates one occasion of a tornado in Yorkshire with the cold downdraught of a storm on a gust front (resembling a small-scale cold front). An account by Lacy (1968) notes several tornadoes which occurred in association with the passage of a cold front.

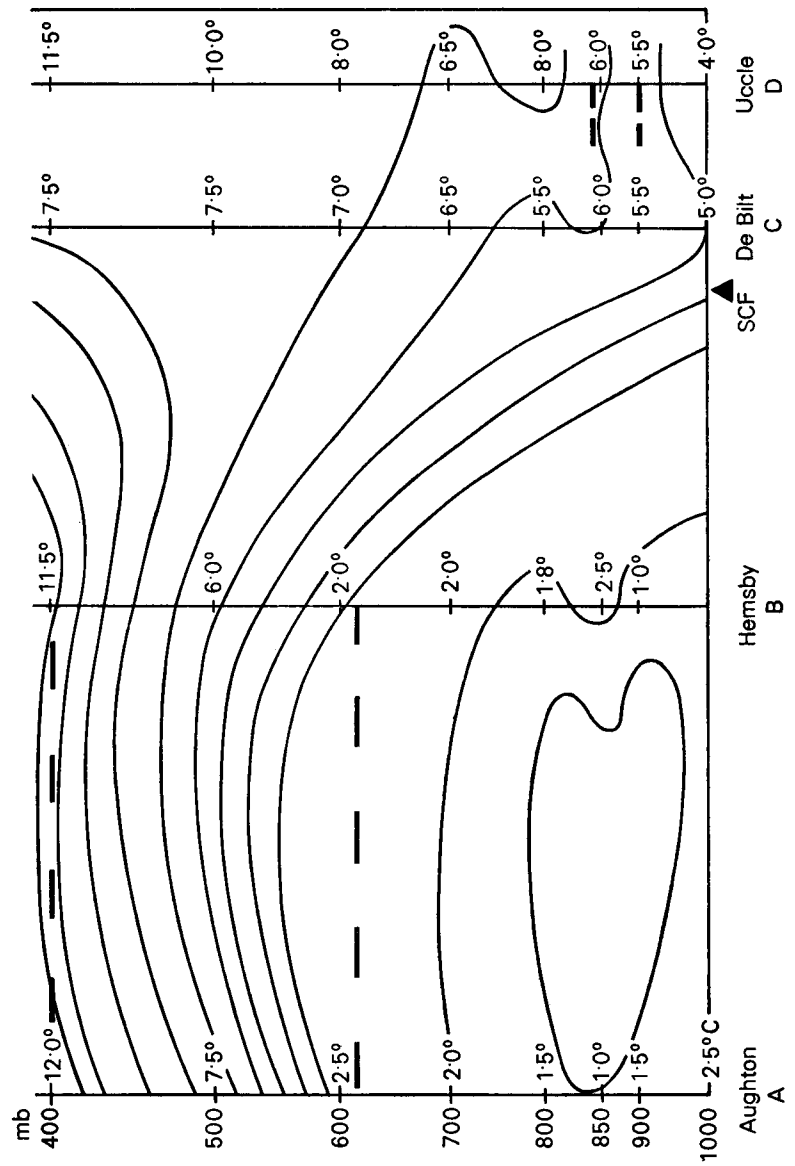

FIGURE 4—AEROLOGICAL CROSS-SECTION AT 1200 GMT ON 3 JANUARY 1978

Full lines are wet-bulb potential temperatures in degrees Celsius. Heavy dashed lines show upper and lower limits of shearing zone. SCF is surface cold front.

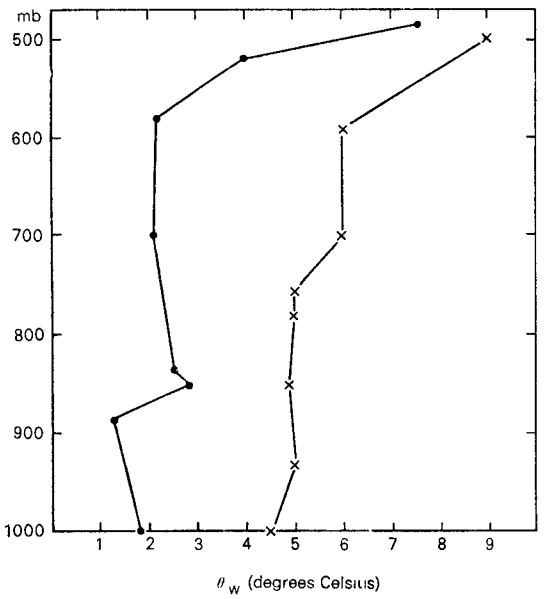

FIGURE 5—PROFILES OF WET-BULB POTENTIAL TEMPERATURE ON 3 JANUARY 1978
·——· Hemsby 1200 GMT × —— × Shoeburyness 1002 GMT

This limited investigation only highlights the more obvious features of the meteorological situation of 3 January 1978. Whilst distressing to those who suffered the consequences, this particular case is seen to be of meteorological interest. It alerts us to the fact that tornadoes are at least as prevalent in winter as in summer (Wright, 1973), and also provides an extreme example of local marked instability and vigorous vertical motion at a kata cold front as inferred by Sansom (1951).

The only tornadoes reported on 3 January 1978 were those at Hull and Newmarket. This localized transient nature of tornado development was aptly described, nearly a century ago as 'a local accident in a very large disturbance' (Abercromby, 1887).

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REVIEWS

Atmospheric Aerosols (*Developments in Atmospheric Science* 7) by S. Twomey, 250 mm × 170 mm, pp. xiv + 302, *illus.* Elsevier Scientific Publishing Company, Amsterdam, The Netherlands, 1977. Price: $49.00, Dfl 120.00.

As Dr Twomey explains in the Foreword to this book, he has not set out to produce an encyclopaedia of the aerosol nor an in-depth study of any subsection. This apology is used to create an account of those parts of the subject in which the author has been a leading research worker. It is a measure of his wide contribution that the result is a substantial study of the physics of the atmospheric aerosol. The approach also has the very great advantage of providing a truly authoritative work, in which his familiarity with the subject matter is very evident.

This characteristic, indeed the whole style of the book, is set by the introductory chapter. The wide span of the atmospheric aerosol size distribution, extending from clusters of a few molecules to precipitation particles, is used to indicate the order of magnitude of various descriptive parameters such as concentration, typical lifetimes and so on. The aim of creating an early numerate 'feel' for the subject is obvious but the importance of a quantitative rather than qualitative understanding is a constantly recurring theme.

The following three chapters provide an account of methods by which new particles are formed in the atmosphere. Creation from the solid, liquid and gaseous phases are all discussed but the formation and subsequent growth of the wet aerosol in the atmosphere is singled out for particular consideration.

The flow of the book is a little uncertain here. The reader is led from a brief introduction to nucleation theory in Chapter 2 to a more thorough treatment with some duplication in Chapter 4, but must return to Chapter 3 for an account of post-nucleation growth by diffusion. Some rearrangement here would create a more logical development, particularly as the discussion of diffusional growth is somewhat out of place in a treatment of hydrodynamic forces on a single particle and an account of Brownian motion.

The next two chapters describe a number of processes which control the size distribution and concentration of aerosol in the atmosphere. Thus in Chapter 5 the physics of coagulation under the action of Brownian motion and van der Waals–London or electrical forces is discussed as a preliminary to developing the coagulation equation. Solutions to the latter are then sought in the submicrometre regime to account for the growth of a population of aerosol of different sizes. Again Twomey is at pains to let the reader see the essence of the problems by frequent use of the simple order of magnitude approach.

Chapter 6 is concerned with the physics of removal processes. Thus the role of turbulent and molecular diffusion in dry removal, nucleation, phoretic and inertial effects in cloud droplet formation and growth, and diffusive and inertial capture by precipitation are all assessed. The importance of each process as a function of aerosol is clearly explained but the order of presentation from dry to precipitation to cloud processes is again confusing and leads to the frequent turning of pages.

The half-way point of the book is reached with the various processes and properties of aerosol net production having been reviewed. The standpoint is now changed to that of the applied scientist seeking to use this information and

to understand the atmospheric role of aerosol. Chapter 7 is devoted to tropospheric phenomena. Thus condensation and ice nucleation and the ensuing precipitation-forming processes are described from the viewpoint of the cloud physicist. Again Twomey's contribution to our understanding of cloud condensation nucleation results in a particularly refreshing and pragmatic approach. Unfortunately the same cannot be said of the ice nucleation section which makes no real attempt to develop an understanding of the physical mechanisms involved.

Chapter 8 is devoted to a brief and not very authoritative account of the stratospheric aerosol before the author returns to the more familiar ground of the optical effects of individual aerosol particles. Here the formal mathematical development of Rayleigh and Mie scattering is much less valuable than his shorter description of the physics of these interactions.

In Chapter 10 the concepts of absorption, scattering and extinction coefficients, developed in the earlier section, are used in conjunction with typical aerosol size distributions to describe the macroscopic effects of aerosol on the radiation field. The use of transmitted or scattered radiation to infer properties of the aerosol and the influence of aerosol on visibility and radiative transfer are all discussed. The text is particularly useful in drawing attention to the ramifications of some commonly used, but occasionally ill-founded, assumptions in this area of the subject.

The electrical properties of aerosol are reviewed in Chapter 11. The process of diffusional differential mobility charging is described and applied to cloud droplets in particular. The relationship between particulate size/concentration and atmospheric conductivity is established and its significance discussed.

Finally, the influence of aerosol on large-scale climate is explored. Feedback processes involving interactions between the radiation field and aerosols, both directly and via their effect on the microstructure of clouds, are discussed in some detail. There is much that is stimulating in this chapter.

Many readers will be disappointed with the scope of this book. Certainly there are significant gaps in the treatment. Heteromolecular condensation receives scant attention despite its importance in gas to particle conversion. No significant discussion of aerosol chemistry is provided, still less of photochemical interactions. The assessment of measurement techniques is conspicuously absent, except in the consideration of cloud condensation nuclei, and even here the field is restricted and very dated. The opportunity to develop the concept of mobility in aerosol size measurement techniques is not taken.

The standard of the diagrams, which are almost all simple line drawings, is often poor. Some are of little conceptual or quantitative value; Figures 1.2, 2.3 and 4.3 are particularly bad in this respect. As discussed above, the overall pattern of the book is occasionally confused, often obscure. There are the usual number of what appear to be proof-reading errors, of course.

Nevertheless, Twomey's treatment of the subject is at its best in those topics where he has contributed personally to their development. Therefore we should not quarrel with his decision to maximize the coverage of this in his book. In such areas, the manner in which the subject matter is presented is, with a few exceptions, clear and stimulating. Thus, the potential user must ask himself whether his interests correspond well enough with the contents described above; when they do, this book will prove to be a valuable source of information.

P. RYDER

Climatic Atlas of the Tropical Atlantic and Eastern Pacific Oceans, by Stefan Hastenrath and Peter J. Lamb. 455 mm × 230 mm, pp. xv + 97, *illus.* The University of Wisconsin Press, Wisconsin; American University Publishers Group Ltd, London, 1977. Price £11.20.

The main content of the publication is a collection of surface climatology charts for the Tropical Atlantic & East Pacific Oceans, giving fields of several meteorological variables for the various months of the year. The Atlantic Ocean within the latitude band 30°N–30°S is fully covered. Part of the East Pacific Ocean within the same latitude band is also covered but this latter region has its western boundary at 110°W and the region analysed also excludes a sector to the south-west of the Galapagos Islands. Consequently there is a substantial part of the Tropical East Pacific not covered by the atlas.

The variables analysed for each of the 12 calendar months are surface pressure, resultant wind, sea surface temperature, horizontal divergence, total cloudiness and precipitation frequency. There are also charts, for the four mid-season months, of horizontal wind steadiness, vorticity, wind stress curl, air/sea temperature difference, specific humidity and lower-level cloudiness. A short text discusses the main features of the charts and there are tabulations of standard deviations of sea surface temperature and wind. One further chart of interest shows the density of data used in the analyses.

The base period for the atlas is 1911–1970. The data source is the several million individual surface marine observations available in the Tape Deck Family 11 (TDF11) deck at the National Climatic Center, Asheville, N. Carolina. This deck is a very valuable data compilation which has been used in some other studies, in particular for the recent revisions of some volumes of the US Navy Department's *Marine Climate Atlas of the World.*

One of the main features of this current publication which distinguishes it from earlier publications is the relatively fine resolution of the analyses and the degree of detail that is present in the charts. The basic resolution of the analyses is 1° lat./long. The surface pressure fields, for example, contain irregularities which would meet with the disapproval of some analysts. However, some of these irregularities occur in areas of plentiful data and indeed in those areas where the authors are not confident of the data base they wisely leave the analyses incomplete. The derived fields of divergence are of interest. They clearly identify the convergence zone of the surface winds over the Tropical Atlantic, and the seasonal migration of the zone. The curl of the wind stress is diagnosed because of its relevance as a forcing function for oceanic motion. Negative wind stress curl calls for upwelling in the southern hemisphere and for downwelling in the northern hemisphere.

The visual presentation of the information is very good. The map projection used is a simple one; the scale of the charts is sufficient to permit detailed scrutiny although the overall dimensions of the atlas are quite small; and the latitude/longitude markings are well arranged. Each of these three considerations is important if such publications are to be of practical use.

The atlas is a welcome advance, both in data content and display format, in the documentation of tropical climatology.

D. B. SHAW

Climatic change, edited by John Gribbin. 250 mm × 190 mm, pp. xi × 280, *illus.* Cambridge University Press, London, 1978. Price £17.50 hardback; £6.50 paperback.

In the preface to this book the editor says he felt the need for a single textbook which would give him an understanding of the basics of climatic change. This remark followed mention of the droughts in the Sahel and Ethiopia, bad harvests in the USSR and so on, and one supposed that the understanding he sought was principally to help him (and others) judge the prospects of this sort of event occurring in the next few decades. This was in 1973 when Volume I of Lamb's 'Climate, Present, Past and Future' had already been published and it was known that Volume II was in preparation. Why, one wonders, did he feel the need for another textbook especially after the appearance in 1975 of 'Understanding Climatic Change' prepared for the United States National Academy of Sciences under the joint editorship of Verner Suomi and Lawrence Gates?

If he felt that the issues involved in the Sahel drought (the northward extent of the south-west monsoon of West Africa) or in the Russian droughts (the amplitude and location of the major troughs and ridges in middle latitudes) have not yet been adequately presented in a textbook one can feel sympathy with his need. These issues probably cover the borderland between the problems of long-range forecasting (1 month to a season) and the shortest scales (a few years to a decade) of climatic fluctuations and represent one of the most formidable problems in meteorology. Was he indeed aiming to illuminate this dark region?

The first three chapters of the book do not suggest he was, covering as they do climatic changes on scales of hundreds to hundreds of thousands of years. The title of Chapter 9—'Short term astronomical effects' is more encouraging but the discussion is mainly limited to events on a time-scale of a few days. The rest of the book gives little reason to think that he was aiming so high, and the book has to be judged as another general text on this over-exposed and under-developed subject of climatic change.

Twelve scientists of varying degrees of eminence have made contributions and the editor has himself written three short chapters and collaborated with Professor Lamb in a chapter I would have thought that doyen of climatic change in Britain quite capable of writing himself. What is the nature of the book that has resulted? It is a hotch-potch without any form or linking theme even though some of the ingredients are of good quality, and deserve a better recipe.

Following the opening three chapters which deal adequately with climates of the distant past, the first section closes with a chapter entitled 'Climatic change in historical times' by Gribbin and Lamb. This is a reduced version of the equivalent chapter in Lamb's Volume II but with an addition which turns out to be more in the nature of advertisement than science. I refer to the presence of the Rossby formula in the discussion of the change in spacing of surface pressure troughs between the periods 1790–1829 and 1900–39. It is reasonably pointed out that on applying this formula the increase in wavelength shown by Lamb's data is too great to be explained by changes in circulation intensity, and 'some slight change of latitude of the strongest upper westerlies must also have taken place with a poleward displacement of a few degrees of latitude'. It is a pity the quantification was not taken a stage further for I estimate that to explain the increase in this way would require a northward shift of 15–20° of latitude. With this improbability recognized perhaps the joint authors would then have asked

themselves whether the data were erroneous or the Rossby formula inapplicable and we might have been spared a piece of pseudo-science.

The next chapter 'The heat balance of the Earth' is written by Budyko, the celebrated Russian climatologist, and contains material that has appeared in *Tellus* and a Leningrad journal: it reflects no credit on the supervision of the Editor. There are too many typographical errors (p. 98 has two very irritating mistakes) and all references to Soviet publications have been left in Cyrillic script which shows the erudition of the printers but does nothing for the reader. The end of this chapter where Budyko concludes that the atmospheric transparency stopped falling in the middle of the 1960s and that the warming due to the increase of CO_2 has now taken over and will continue, perfectly illustrates the kind of madness that seems to infect workers in this field when they move from analysis to prediction.

Chapter 6—'Recent changes in snow and ice'—has been written from a very narrow viewpoint: the influence of snow and ice on climate change is treated as a primary rather than a feedback effect. The differences in the change of total snow and ice cover between winter and summer for the two hemispheres, which are surely mainly due to their different thermal capacity, is presented in a graph ostensibly showing the important part played by the extent of snow and ice in the different climates of the northern and southern hemispheres.

Section 4—'Modelling the changing climate'—opens with a diffuse chapter on the role of the oceans and continues with one on the use of numerical models in studying climate change. This and the next chapter on the interpretation of results from numerical models illustrate how far there is yet to go in this potentially very important art.

The book concludes with a section entitled 'Climate and Man'. Kellogg in a carefully reasoned chapter examines the effect of man-made changes in the constitution of the atmosphere on temperature and concludes that the so-called 'anthropogenic' aerosols may not have stopped increasing as Budyko says. More important, he argues that we cannot be at all certain what their effect has been on northern hemisphere temperature during these last three decades. Schneider, known through his book 'The Genesis Strategy' for his passionate concern that governments should act to insure against the direct effects of climatically induced crop failures, and Temkin, also from the National Center for Atmospheric Research in Boulder, Colorado, USA, co-operate to describe the effect of climate on man.

Professor Flohn contributes an interesting appendix most of which, however, like Chapter I and II, has little relevance to events on a time-scale of a few years.

This is a nicely produced book, as you might expect from the Cambridge University Press, but assuming they wanted to have a text on this subject on the market it says little for their judgement that they entrusted its editing to an astrophysicist: the tough problems in this field, apart from those concerning variations in the Solar Constant, are meteorological not astrophysical.

M. K. MILES

NOTES AND NEWS

Retirement of Mr E. J. Sumner

Mr E. J. Sumner, Assistant Director (Systems Development), retired from the Meteorological Office on 5 June 1978 after a career of over 36 years.

Having graduated with honours in mathematics at Oxford, Eric Sumner joined the Office in 1941 and was soon involved in forecasting at RAF stations. He held a commission as a Flying Officer in the RAFVR from 1943 to 1946, at which time he was demobilized and took up civilian duties as a Senior Scientific Officer. After a short spell in climatology at Harrow, he joined the newly formed Forecasting Research Branch at Dunstable in 1948. His papers on vertical stability in synoptic development, and on blocking, are still worth consulting some 25 years later. In 1953, he moved to the Central Forecasting Office where he proved his skills as a forecaster and shrewd synoptician.

He was promoted to Principal Scientific Officer in 1958 at a time when the Office was acquiring its first electronic computer (METEOR) for research into numerical weather forecasting. It was not long before the possibilities of using computers for automatic data processing were realized, both by research workers and by those engaged in developing climatological services. Mr Sumner was given charge of the data processing section of the newly formed Support Services Branch, and moved with it to Bracknell in 1961. Shortly afterwards the Branch took over responsibility for the operation of METEOR, and was able to plan the provision of an integrated service of computing and data processing to meet the coming explosion in demand. In a review article in 1960, Mr Sumner provided a penetrating and far-sighted analysis of the dramatic developments which were to occur in the fields of meteorological computing and automatic data processing.

Throughout the Sixties, he was to be at the forefront of the rapidly changing technology of electronic computing devices. In 1964 the data processing section became a Branch, with added responsibilities for the storage of climatological data and for the development of automatic line drawing and plotting. The introduction of operational numerical forecasting with tight time schedules, following the acquisition of the KDF-9 computer in 1965, ushered in the present frenetic era of real-time computing and underlined the need for highly professional computer management. Against such a background of change, it is noteworthy that Mr Sumner was able to look so far ahead with such vision, though sometimes setting aside the practical problems of the present in his eagerness to reach out for the solutions of the future. His forthright advocacy of new possibilities has enlivened many an otherwise dull meeting.

With the introduction of computer-based systems into meteorological telecommunications, and with the need for these to be linked both to the data-processing computers and to automated outstations, a new Deputy Directorate was created in 1971 comprising Data Processing, Telecommunications and Systems Development Branches. It is never easy to establish a completely new branch, but Mr Sumner applied himself to this task with characteristic enthusiasm. Under his leadership, readily retrievable and machinable data archives were established, methods were developed for transcribing field data into computer-assimilable form, certain functions of the Library were automated, it became possible to manipulate satellite imagery by computer techniques and the basic design features of automated outstations were determined.

As is not uncommon amongst mathematicians, Eric Sumner derives much pleasure from music and is a pianist of some accomplishment. More recently his early efforts with brush and canvas have shown much promise. We wish him and Mrs Sumner a long and happy retirement in their new home in Shropshire.

M. J. BLACKWELL

International Conference on Climate and History at the University of East Anglia

The University of East Anglia are proposing to hold an international conference on climate and history on 8–14 July 1979 with contributions by climatologists, historians and archaeologists. It is hoped that workers in all three fields will be able to inform each other of the present state of knowledge of the climatological record and of the impact of climate and climatic change on past and present societies, that areas of potentially useful co-operation will be identified, and that contacts between individuals will be set up.

The conference is being planned to include sessions on the following topics:

(1) The illustration of methods used by each discipline and the increasing opportunities of using various kinds of 'fossil' records (such as tree-rings, varves, isotope studies and so on) combined with historical materials.

(2) General reviews of the conclusions so far reached in fields of common interest to climatologists, historians and archaeologists.

(3) Further discussions of (i) climate in prehistory; (ii) climate in the documented past; (iii) the past, present and possible future significance of the interrelation between climate and human activities; (iv) the implications of climatic change for the development and history of agriculture, fisheries, exploration, human health and demography, economic development, times of unrest etc.

The proceedings will include papers that discuss these matters in relation to specific problems, periods and parts of the world.

Potential participants should contact:

The Conference Secretary (Climatic and History Conference)
Climatic Research Unit,
School of Environmental Sciences.
University of East Anglia,
Norwich NR4 7TJ,
England,

as soon as possible.

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